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(54) Fuel Mixer

(57) A liquid fuel/air mixer comprises a tubular airflow duct 1 having a flared entry 2. Liquid fuel is introduced by circumferentially spaced injectors 8 and atomised by air jets 10 located co-axially with the injectors or immediately downstream of them. Fuel and air may be directed radially from common orifices having a variety of arrangements, or fuel may be injected in a downstream direction towards radially directed air jets. Main air supply to the mixer may be by way of a flow straightener 20.

Fig. 1.

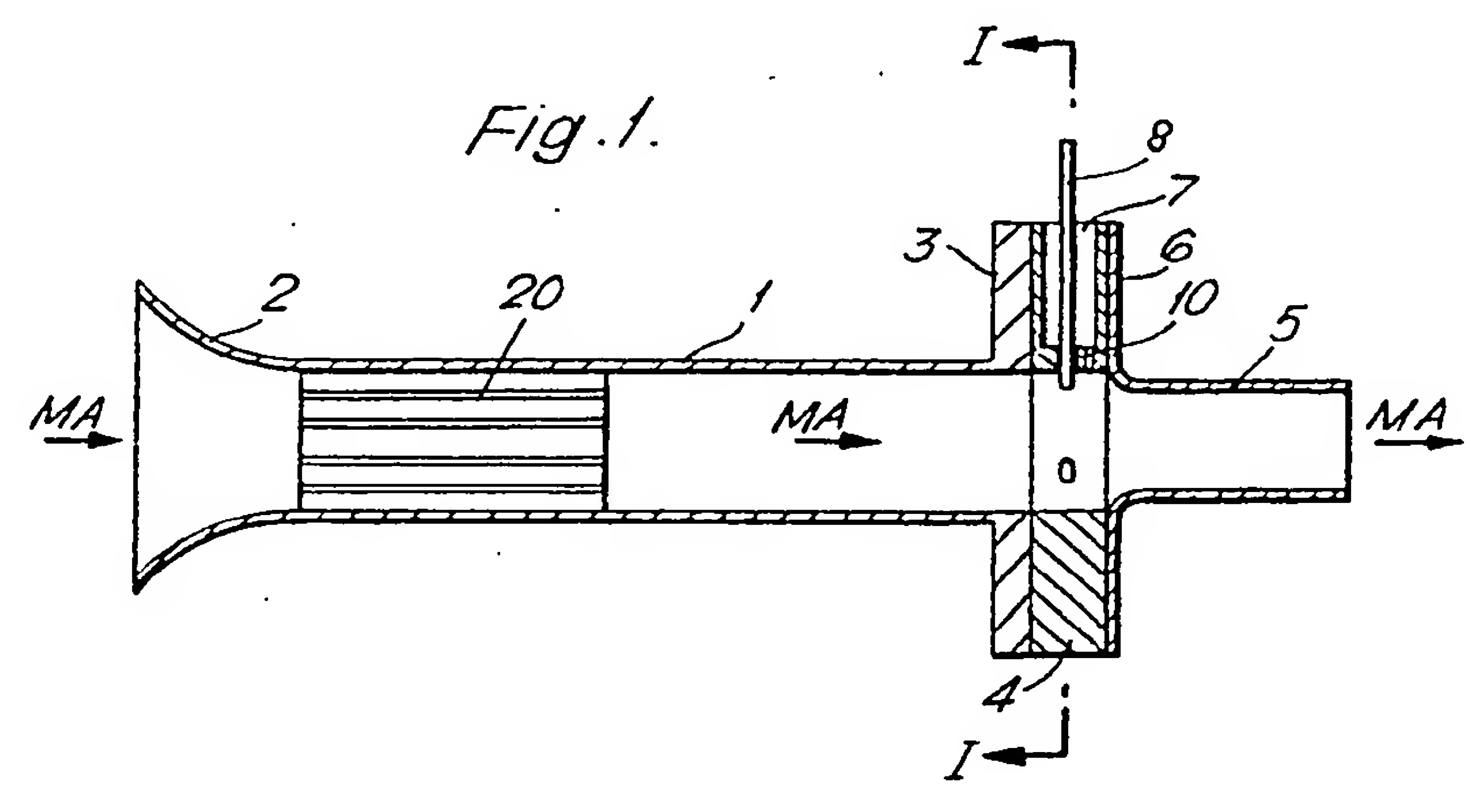

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Fig.1.

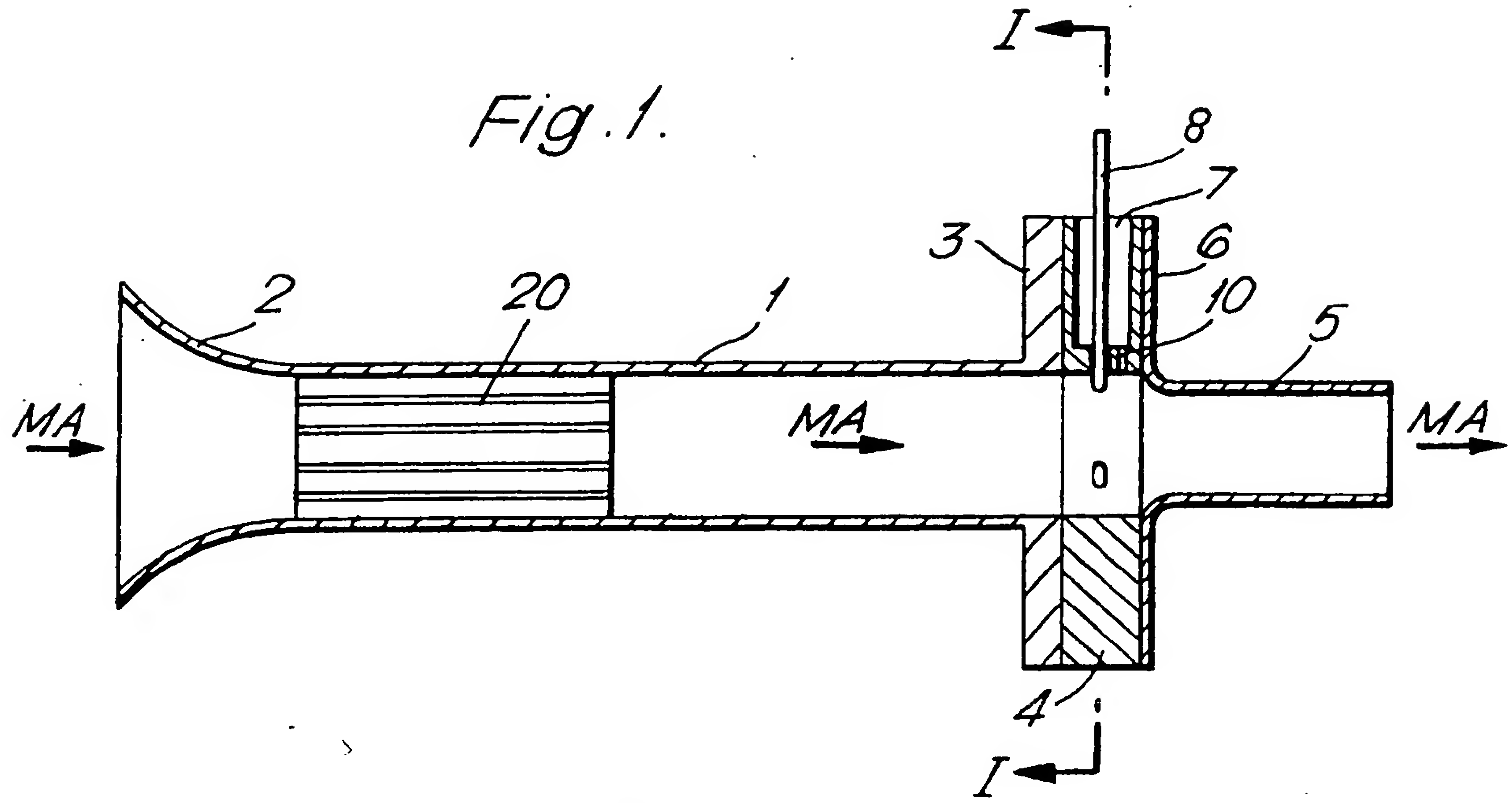


Fig.2.

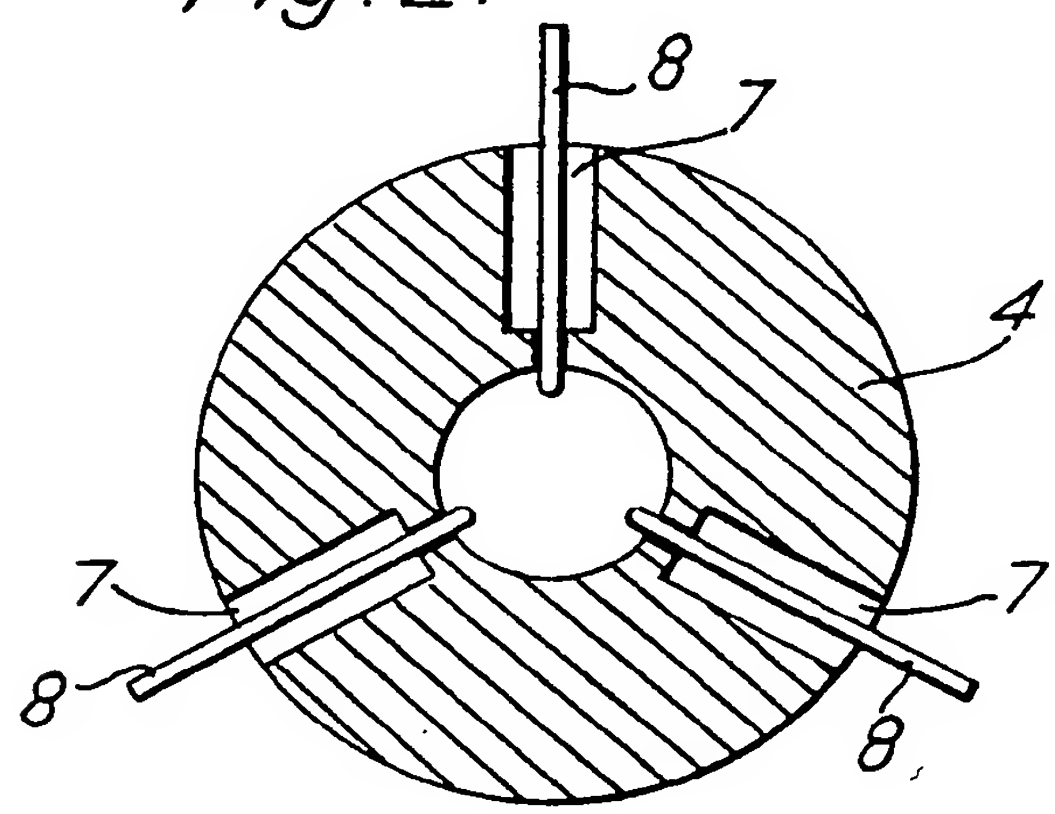


Fig.3.

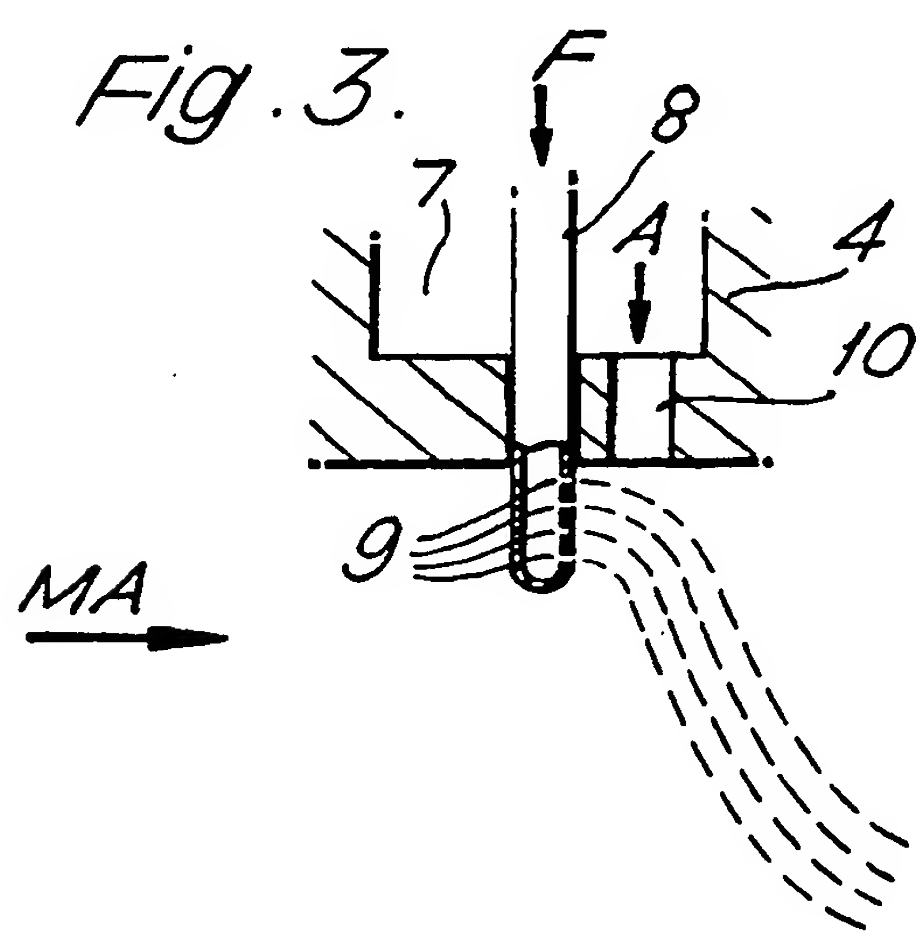


Fig.4a.

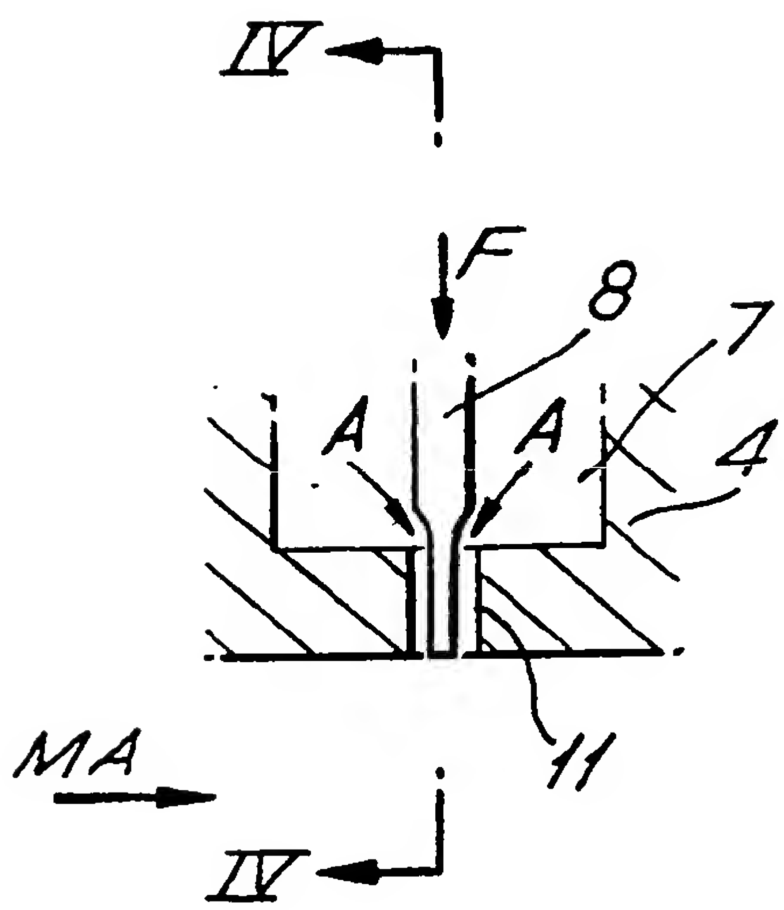


Fig.4b.

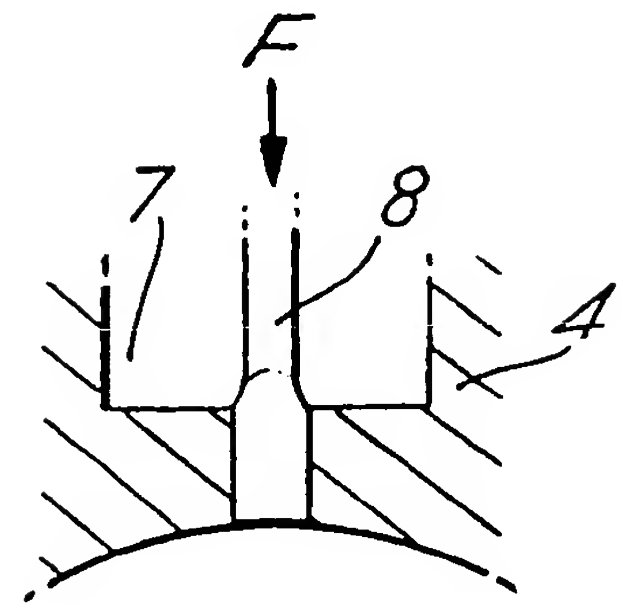


Fig. 5.

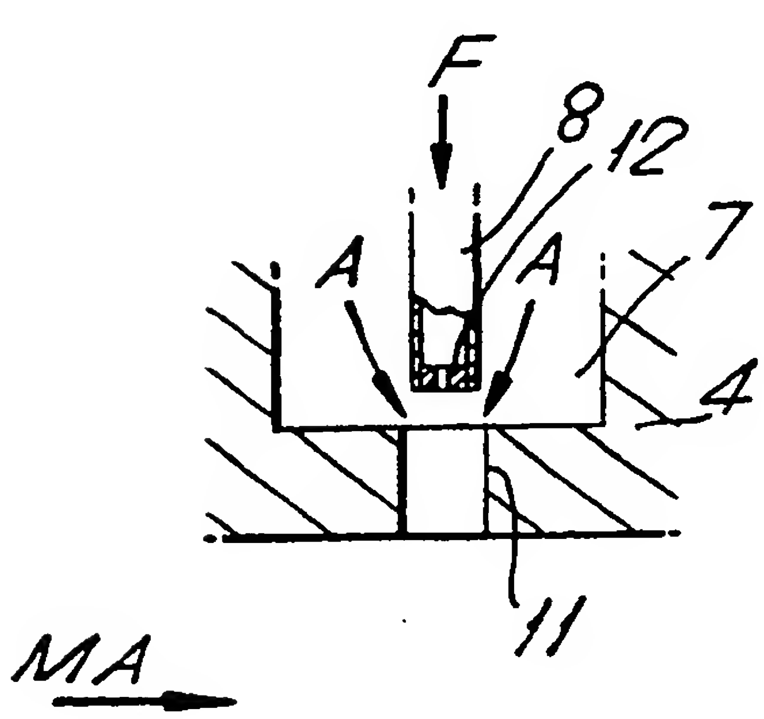
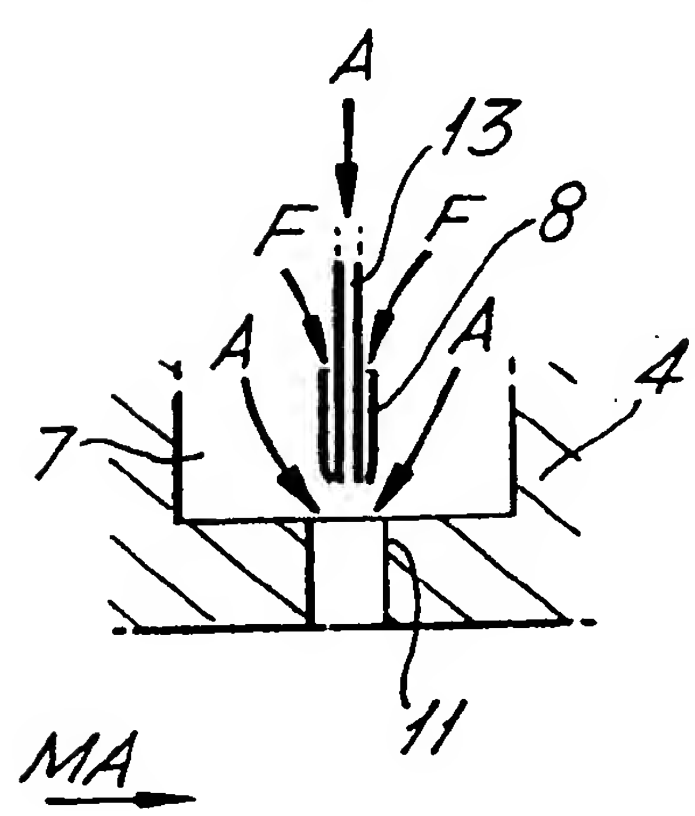


Fig.6.



SPECIFICATION

Improvements In or Relating to Fuel Mixers

This invention relates to fuel mixers of the kind in which liquid fuel is injected into an air stream.

To avoid unnecessary atmospheric pollution it is desirable that oxides of nitrogen (NOx) in the emissions from combustion systems such as are used in gas turbine power plants are maintained at the lowest possible level. This can be achieved by the use of lean mixtures of the fuel and air used for combustion and particularly where the fuel vaporisation and mixing process is substantially completed before burning commences.

However these conditions are also conducive to spontaneous ignition of the fuel-air mixture which is particularly undesirable if it occurs within the mixing system.

Spontaneous ignition can be avoided if the vaporisation and mixing can be accomplished in less than the ignition delay time of the mixture. The latter varies with the fuel to be used, the fuel-air ratio and the operating conditions of temperature and pressure. Depending on the operating conditions and flow velocity in the airstream there will be a limitation on the mixing length which must not be exceeded if spontaneous ignition is not to occur.

The requirements of an effective mixer are thus, the production of a fine fuel spray and, secondly, distributing the fuel in controlled manner to give uniform dispersal in as short a length as possible, both over a range of operating conditions.

The present Invention utilises the introduction of high pressure air coincidently with fuel jets or slightly downstream of them on the same radial alignment relative to duct axis so as to ensure good atomisation of the fuel and to provide necessary control over fuel placement in an airstream. The penetration of the fuel into the air-stream in such conditions is amenable to calculation and can be varied to suit differing operating conditions.

According to the invention, a fuel mixer comprises an air flow duct, a plurality of fuel injectors spaced circumferentially around the duct and air inlets located substantially coincidentally with the fuel injectors or immediately downstream of them on the same circumferential alignment for the discharge of high pressure air across the duct.

In one embodiment, fuel is discharged with an axial component in a downstream direction relative to flow through the duct.

Embodiments of the invention will now be described, by way of example only, with reference to the accompanying diagrammatic drawings, of which:—

Figure 1 is a longitudinal section of a fuel mixer according to the invention,

Figure 2 is a cross-sectional view of the mixer of Figure 1 taken on the line I—I in Figure 1.

Figure 3 is a scrap view of a part of Figure 1 on a larger scale showing the arrangement for injecting fuel and high pressure air,

Figure 4*a* is a similar view to that of Figure 3 showing another fuel and air injection arrangement, and Figure 4*b* is a further view taken on the line IV—IV in Figure 4*a*,

Figures 5 and 6 are further views corresponding to Figures 3 and 4*a* of other alternative arrangements for fuel and air injection.

Referring to the drawings, the fuel mixer shown in Figures 1 and 2 includes a circular air flow duct 1 having a bell-mouth entry 2 at one end and a flange 3 at the other end. A flow straightener 20 is mounted in the duct adjacent to the bell-mouth. An annular Injection flange 4 having an internal diameter corresponding to the duct 1 is attached to the flange 3 and a mixing tube 5 is in turn attached to the injection flange by a flange 6. The flanges 3, 4 and 6 are conventionally held together by through bolts (not shown). The internal diameter of the mixing tube 5 is less than that of the duct 1 and is flared at its flanged end to give a smoothly-contoured transition. The direction of air flow through the mixer is indicated by the arrows MA.

The injection flange 4 has three circumferentially-spaced pockets 7 extending radially inwardly from its outer circumference (see also Figure 2). Fuel injectors 8 located coaxially in the pockets 7 extend into the central aperture of the injection flange 4.

The fuel injectors 8 comprise tubes which are closed at their radially inner ends as shown in greater detail in Figure 3. Four holes 9, spaced axially relative to the injection, are drilled in the wall of each injector adjacent to the closed ends within the central aperture of the injection flange and are directed in a downstream direction with respect to air flow through the mixer. Immediately downstream of each injector and on the same radial alignment, orifices 10 extend from the bases of the respective pockets 7 into the central aperture of the injection flange. The injectors 8 and the pockets 7 are connected respectively to a source of liquid fuel and a high pressure air supply.

In operation, liquid fuel flows through the injectors 8 as shown by the arrow F in Figure 3 to issue through the holes 9 where it meets jets of high velocity air flowing from the pockets 7 through the orifices 10 as indicated by the arrow A. The high velocity air jets atomise and entrain the fuel and carry it across the duct along a curved trajectory as indicated by the dotted lines T. The fuel is further atomised and mixed with the airflow through the duct while passing along the mixing tube 5 to give a substantially uniform distribution at the exit therefrom.

Optimum performance can be maintained over a wide range of operating conditions by adjusting the high velocity air flow to compensate for changes in temperature, pressure, fuel flow or air flow through the duct. It has been found that adequate mixing can be achieved with a mixing tube having a length equal to approximately two diameters whereas the length at which

spontaneous ignition is likely to occur would be distinctly greater than this.

Various other arrangements of injectors can be used, for instance their number may be increased though preferably in odd numbers so as to avoid diametral location which could lead to local overconcentrations.

The numbers of holds 9 in Figure 3 may be increased or reduced and alternative injector arrangements are shown in Figures 4*a* and 4*b*, 5 and 6.

In these figures the same reference numerals and letters are used to denote corresponding integers to those in the previous figures.

In all of these arrangements, an orifice 11 connecting the pocket 7 to the main air flow duct is disposed coaxially with the injector 8 rather than downstream of it. In the arrangement of Figures 4*a* and 4*b*, the injector is open at its radially inner end which is flattened, e.g. by crimping, to bisect the orifice 11 as shown so that high pressure air can flow on either side of the broad jet of fuel issuing from the injector thus enhancing entrainment of fuel by the high pressure air. The injector does not extend into the main air flow duct.

Turning now to Figure 5, the injector 8 terminates short of the orifice 11 and is open-ended but having a flow restrictor 12 inserted therein. The flow restrictor 12 has a small bore which will discharge a very fine jet of fuel through the aperture 11 to be entrained by the air passing therethrough towards the main air flow duct.

In Figure 6, the injector 8 is provided with a small bore tube 13 mounted coaxially within it and terminating at the open end of the injector, whereby additional high pressure air can be introduced at the centre of a jet of fuel issuing from the injector before passing through the orifice 11 to the main air flow duct.

Tests with fuel mixers according to the invention have shown a notable "turn-down" wherein it has proved possible to light up at a pressure of 1 to 2 atm (abs) and run up to pressures in excess of 20 atm whilst maintaining a constant main air flow velocity and fuel-air ratio with efficient low-NOx combustion at all pressures above approximately 3 atm by simply maintaining a constant effective-dynamic-pressure ratio between the atomising and main air flows. Experience of other fuel mixing systems suggests that their turn-down capability is much more restricted.

A fuel mixer according to the invention can be readily adapted to automatic control, possibly by means of a simple mechanical regulator but an electronic control system would probably be necessary for precise operation with minimum consumption of high pressure air.

It might be advantageous in some circumstances to replace the mixing tube by an annular duct in order to avoid excessive local concentrations of fuel which could occur near a tube axis as a result of over penetration of insufficiently atomised fuel.

Fuel mixers according to the invention are suitable for use with a variety of combustion systems, such as, for instance, boiler furnaces, catalytic reactor combustors or in gas turbines. In the latter case, the requirement for high pressure atomising air may rule out aero engine applications but industrial and, possibly, marine engine usage is believed to be viable.

Claims

1. A fuel mixer comprising an air flow duct, a plurality of fuel injectors spaced circumferentially around the duct and air inlets located substantially coincidentally with the fuel injectors on the same circumferential alignment for the discharge of high pressure air across the duct.

2. A fuel mixer according to claim 1 in which an air inlet is located immediately downstream of each fuel injector.

3. A fuel mixer according to claim 1 or claim 2 in which the fuel injectors are arranged to discharge fuel with an axial component in a downstream direction relative to air flow through the duct.

4. A fuel mixer according to claim 3 having fuel injectors comprising tubes extending into the duct and each provided with at least one downstream directed fuel discharge orifice.

5. A fuel mixer according to claim 1 having an odd number of fuel injectors arranged to discharge fuel substantially radially across the duct.

6. A fuel mixer according to claim 5 in which the air inlets are disposed co-axially with the respective fuel injectors.

7. A fuel mixer according to claim 5 or claim 6 in which the air inlets substantially surround the fuel injectors.

8. A fuel mixer according to claim 6 or claim 7 in which the fuel injectors are arranged to discharge fuel through the air inlets.

9. A fuel mixer according to any previous claim further comprising a mixing tube co-axial with the duct and disposed downstream of the fuel injectors.

10. A fuel mixer according to claim 9 in which the length of the mixing tube is equal to approximately twice its diameter.

11. A fuel mixer substantially as herein described with reference to the accompanying drawings.

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